

REMARKS

Claims 1-31 are pending in this application. Claims 1-31 stand rejected. Claims 1, 14, 19, 26 and 27-31 have been amended. Support for the amendments to the claims can be found beginning on page 6 line 20 through page 9 line 5 and elsewhere in the specification. Claims 1-31 remain in the application. Applicant respectfully traverses the rejections for the reasons expressed herein below.

A. Rejection of Claims 1-2, 5 and 14-15 under 35 U.S.C. § 102(e)

Claims 1-2, 5 and 14-15 stand rejected under 35 U.S.C. § 102(e) as being anticipated by United States Patent No. 5, 807,785, issued to Ravi ("Ravi"). Applicant respectfully traverses this rejection and requests reconsideration of claims 1-2, 5, and 14-15.

Claims 1-2, 5 and 14-15, as amended, recite a method of forming dielectric layer in an opening having an aspect ratio of greater than about two. A first dielectric layer is formed in the opening at a first deposition rate wherein a portion of the opening not filled with the first dielectric layer has an aspect ratio of not greater than about two. A second dielectric layer is formed at a second deposition rate greater than the first deposition rate over the first layer, filling the portion of the opening not filled with the first dielectric layer, and has a top surface that is not within the opening such that voids are not substantially present in the opening.

As set forth on page 6, lines 10-14 of the specification, a problem exists in the art in that openings having aspect ratios greater than about two are difficult to fill at relatively high deposition rates and often suffer from shadowing effects. The present

invention addresses this problem by providing good gap-fill characteristics, even at high aspect ratios of greater than about two. In particular, it has been found that the first dielectric layer may be formed at a relatively low deposition rate, when the impingement rate is low, so that voids between the structures caused by the shadowing effect are either eliminated or greatly reduced. The first dielectric layer provides improved protective, insulating and capacitive qualities in the critical gap areas or openings between the structures in order to protect the circuit from impurities, moisture, and stress related impacts. The second dielectric layer may then be formed at a deposition rate higher than the first dielectric layer. As a result, voids are substantially not present in the opening.

Ravi discloses a low dielectric constant silicon dioxide sandwich layer. As stated from column 8, line 56 to column 10, line 60, the Ravi sandwich layer comprises a first layer and a second layer. The first layer is formed using a plasma-enhanced chemical vapor deposition (PECVD) process that partially fills a narrow gap between conductive lines. The first layer is formed at a dielectric constant less than 4.0 using tetraethylorthosilicate (TEOS) in combination with ozone and a fluorine-containing compound. The second layer is formed over the first layer using a subatmospheric chemical vapor deposition (SACVD) process. The second layer is formed with TEOS and ozone, and no dopants, to give a USG layer at a dielectric constant greater than 4.0. As stated in column 2, lines 28-32, Ravi discusses that, as conventionally known in the art, a SACVD layer (the second layer of Ravi) is formed using a relatively slow deposition rate and a PECVD layer (the first layer of Ravi) is deposited more quickly. Furthermore, the Ravi invention is primarily concerned with filling in gaps having an

aspect ratio of between 1.5:1 up to 2:1. Therefore, by appropriately choosing the thickness of the respective layers, Ravi is said to provide a means whereby the dielectric constant may be adjusted to a value which is a combination of the dielectric constants of the two different layers.

It is axiomatic that prior art is anticipatory only if every element of the claimed invention is disclosed in a single item of prior art in the same form as arranged in the claim. More specifically, anticipation is established only when a single prior art reference discloses, expressly or under principles of inherency, each and every element of a claimed invention. MPEP §2131 (emphasis added). Such disclosure must also be shown in as complete of detail as is contained in the patent claim. MPEP §2131.

Unlike claims 1-2, 5, and 14-15 of the present invention, Ravi does not teach a method of forming a dielectric layer in an opening having an aspect ratio greater than about two with a first dielectric layer in the opening wherein a portion of the opening not filled with the first dielectric layer has an aspect ratio of not greater than about two. As stated above, the Ravi invention is said to be primarily effective for filling in gaps having an aspect ratio of between 1.5:1 up to 2:1. Furthermore, Ravi does not teach a first dielectric layer formed at a first deposition rate or a second dielectric layer formed at a second deposition rate greater than the first deposition rate. In contrast to recited claims 1-2, 5, and 14-15, the first layer of Ravi (the PECVD layer) is deposited quickly while the second layer (the SACVD layer) is formed at a relatively slow deposition rate.

It is asserted that Ravi does not disclose the method recited in independent claims 1-2, 5 and 14-15 or the advantages arising therefrom. Based upon

the facts and principles outlined above, Applicant submits that Ravi does not anticipate claims 1-2, 5, and 14-15. Accordingly, withdrawal of the rejection under 35 U.S.C. § 102(e) in view of Ravi is respectfully requested.

Furthermore, it is admitted that Ravi does not suggest the method recited in claims 1-2, 5, and 14-15. To establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the combination of prior art. MPEP §2143.03. In addition, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. MPEP §2143. Put another way, the mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination or modification. MPEP §2143.01. In addition, it must be remembered that a prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention. MPEP §2141.02.

Ravi does not teach or suggest all of the claim limitations of the present method. As stated above, Ravi does not teach a method of forming a dielectric layer in an opening having an aspect ratio greater than about two with a first dielectric layer in the opening wherein a portion of the opening not filled with the first dielectric layer has an aspect ratio of not greater than about two. The Ravi invention is primarily concerned with filling in gaps having an aspect ratio of between 1.5:1 up to 2:1. However, it has been found that the method recited in the claims 1-2, 5, and 14-15 is effective for filling openings having an aspect ratio greater than about two. As previously discussed,

openings having aspect ratios greater than two are difficult to fill at relatively high deposition rates and often suffer from shadowing. The recited method clearly contemplates openings having aspect ratios greater than about two.

Furthermore, Ravi does not teach or suggest a first dielectric layer formed at a first deposition rate or a second dielectric layer formed at a second deposition rate greater than the first deposition rate. Indeed, it is submitted that Ravi teaches away from the present invention. The present invention teaches a first dielectric layer formed at a first deposition rate and a second dielectric layer formed at a second deposition rate greater than the first deposition rate. In contrast, Ravi teaches away from this recited arrangement. In particular, Ravi teaches a first layer that is deposited at a quick deposition rate and a second layer that is deposited at a relatively slow deposition rate. Accordingly, Applicant submits that Ravi does not render the present invention obvious and, indeed, would lead one of ordinary skill in the art away from the recited claims.

B. Rejections Under 35 U.S.C. § 103

1. Rejection of Claims 3, 7-8, 16-19, and 20-25 over Ravi in view of Kocmanek

Claims 3, 7-8, 16-19, and 20-25 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Ravi as applied to claims 1-2, 5 and 14-15 and further in view of United States Patent No. 5,252,520 issued to Kocmanek et al. ("Kocmanek"). Applicant respectfully traverses this rejection and requests reconsideration of claims 3, 7-8, 16-19, and 20-25.

Claims 3, 7-8, 16-19, and 20-25, as amended, recite a method for forming a dielectric layer on a substrate including forming a first dielectric layer at one process

setting and forming a second dielectric layer at a second process setting and, wherein, the deposition rate for the second dielectric layer is greater than the deposition rate for the first dielectric layer. Process variables that may be adjusted include temperature, pressure, dopant concentration, flow rate and shower head spacing.

Kocmanek teaches a method for forming a multi-layer dielectric such that the initial film density of the deposited dielectric is higher than or equal to that of the bulk of the first and second dielectric. This is accomplished by altering the process settings, specifically by reducing the flow rate of the precursor gas during the initial portion of the deposition process relative to the flow rate during the remainder of the deposition process. As set forth in column 1, lines 40-55, the process variation is particularly directed to formation of portions of the second dielectric layer.

For the reasons cited above that distinguish claims 1-2, 5, and 14-15 of the present invention from the teachings of Ravi, the Applicant respectfully asserts that claims 3, 7-8, 16-19, and 20-25, as amended, are also clearly distinguishable from the teachings of Ravi. Indeed, because Ravi teaches away from the claims of the present invention, it is respectfully submitted that Ravi may not be applied, either alone or in combination, to reject claims 3, 7-8, 16-19, and 20-25. Further, it is submitted that nothing in Kocmanek, if combined with Ravi, teaches or suggests the formation of a multi-layer dielectric in an opening having an aspect ratio greater than about two, wherein a first dielectric layer is formed at a first deposition rate and a second dielectric layer is formed at a second deposition rate greater than the first deposition rate. Unlike the claims of the present invention, Kocmanek is primarily concerned with controlling the density of the initial portion of the first dielectric layer by changing the flow rate of

the precursor gas, and is particularly directed to process variation relating to formation of the second dielectric layer, rather than with controlling the deposition rate of the second dielectric layer relative to the first layer, as recited in claims 3, 7-8, 16-19, and 20-25.

Accordingly, withdrawal of the rejection of claims 3, 7-8, 16-19, and 20-25 under 35 U.S.C. § 103(a) over Ravi in view of Kocmanek is respectfully requested.

2. Rejection of Claim 4 over Ravi in view of Chou

Claim 4 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Ravi as applied to claims 1-2, 5, and 14-15, and further in view of U.S. Patent No. 5,861,345 issued to Chou et al ("Chou"). Applicant respectfully traverses this rejection and requests reconsideration of claim 4.

Chou teaches an *in situ* inter-dielectric process for forming multilevel metal structures on a semiconductor. The method comprises forming an SOG layer on an uneven semiconductor surface, treating the surface of the SOG layer with plasma in a PECVD chamber, and forming a PECVD layer on the treated surface in the same PECVD chamber.

For the reasons discussed above, claim 4, which depends from amended claim 1, is clearly distinguishable from the teachings of Ravi. Indeed, because Ravi teaches away from the claims of the present invention, it is respectfully submitted that Ravi may not be applied, either alone or in combination, to reject claim 4. Further, nothing in Chou if combined with Ravi teaches or suggests the method recited in claim 4. Specifically, neither Chou alone nor in combination with Ravi teaches a method of

forming a first dielectric layer at a first deposition rate in an opening having an aspect ratio greater than about two and wherein a second dielectric layer is formed at a second deposition rate greater than the first deposition rate.

Accordingly, withdrawal of the rejection of claim 4 under 35 U.S.C. § 103(a) over Ravi in combination with Chou is respectfully requested.

3. Rejection of Claim 26 over Ravi in view of Lin

Claim 26 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Ravi as applied to claims 1-2, 5, and 14-15 and further in view of U.S. Patent No. 5,969,409 issued to Lin ("Lin").

Claim 26, as amended, recites a method of forming a first dielectric layer in an opening at a first deposition rate completely filling the opening, the opening having an aspect ratio greater than about two, and forming a second and final dielectric layer at a second deposition rate greater than said first deposition rate over the first dielectric layer such that voids are substantially not present in the opening.

Lin teaches a wafer planarization process that combines a high-density plasma chemical vapor deposition (HDP-CVD) process with a chemical mechanical polishing (CMP) process. The process employs at least three dielectric layers to form the final semiconductor device.

For the reasons stated above that render claims 1-2, 5, and 14-15 clearly distinguishable from Ravi it is asserted that claim 26, which recites a similar method to claims 1-2, 5, and 14-15, is also clearly distinguishable from the teachings of Ravi. Moreover, because Ravi teaches away from the claims of the present invention, it is

respectfully submitted that Ravi may not be applied, either alone or in combination, to reject claim 26. Additionally, neither Lin alone nor if combined with Ravi disclose a method for forming a dielectric layer in an opening having an aspect ratio greater than about two wherein a first dielectric layer is formed at a first deposition rate and a second dielectric layer is formed on the first dielectric layer at a second deposition rate greater than the first deposition rate. Indeed, the Examiner only relies on Lin for the limited teachings of forming a dielectric layer completely filling the opening.

Accordingly, withdrawal of the rejection of claim 26 under 35 U.S.C. § 103(a) over prior art as recited by Ravi and Lin is respectfully requested.

4. Rejection of Claims 6, 9-13, and 27-31 over Ravi in view of Jang

Claims 6, 9-13, and 27-31 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Ravi as applied to claims 1-2, 5, and 14-15 and further in view of U.S. Patent No. 5,563,104 issued to Jang et al. ("Jang").

Claims 6, 9-13, which depend from claim 1, and 27-31 teach the formation of a dielectric layer wherein the first layer is formed at a first deposition rate and a first process setting and the second layer is formed at a second deposition rate greater than the first deposition rate and a second process setting having a predetermined relationship with the first process setting. The first process setting and the second process setting may be temperature, reactor chamber pressure, dopant concentration, flow rate and shower head spacing.

Jang teaches a three-step deposition process that includes a PECVD deposition step and a two-step low and high temperature ozone-TEOS process to form a three-layered integrated circuit.

For the reasons discussed above that distinguish claims 1-2, 5, and 14-15 of the present invention from the teachings of Ravi, Applicant asserts that claims 6, 9-13, and 27-31 which recite similar limitations for claims 1-2, 5, and 14-15, are also clearly distinguishable from Ravi. Moreover, because Ravi teaches away from the claims of the present invention, it is respectfully submitted that Ravi may not be applied, either alone or in combination, to reject claims 6, 9-13, and 27-31. In addition, Jang neither alone nor if combined with Ravi, teaches or suggests a method of forming a two-layered dielectric device in an opening with an aspect of greater than about two at the deposition rates and process conditions recited in the claims. Indeed, the Examiner only relies on Jang for the limited teaching of the ability to vary process settings during the formation of a multi-layered dielectric layer, and not for the specific process settings recited in amended claims 6, 9-13, and 27-31.

Accordingly, for at least the reasons discussed above, withdrawal of the rejection to claims 6, 9-13, and 27-31 under 35 U.S.C. § 103(a) over the combination of Ravi and Jang is respectfully requested.

CONCLUSION


Applicant submits that claims 1-31 of the present invention recite a novel and non-obvious method of forming a dielectric layer. The cited references neither teach nor suggest the claimed method. In view of the foregoing, Applicant respectfully

submits that the subject application is in condition for allowance. Accordingly, reconsideration of the rejections and allowance of the claims at an early date are earnestly solicited.

If the undersigned can be of assistance to the Examiner in addressing issues to advance the application to allowance, please contact the undersigned at the number set forth below.

Respectfully submitted,

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Date


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